The ontology of neglect. Consciousness and Cognition

Elsevier Editorial(tm) for Consciousness and Cognition
Manuscript Draft

Manuscript Number: CONCOG-04-30R2

Title: The Ontology of Neglect

Article Type: Regular Article

Keywords: unilateral neglect; ontology; time, temporal features; allochiria.

Corresponding Author: Dr. Cristina Becchio Universita of Torino

Other Authors: Cesare Bertone, Prof Center for Theoretical and Applied Ontology

*** Cover Letter**

Turin, 2/12/2004

Editorial Office CCOG
Elsevier Science USA
525 B Street, Suite 1900
San Diego, CA 92101-4495
USA

Dear Sirs,

Thank you very much for your comments and critics. Following the indications of the reviewers we have revised the conclusive section and checked both text and references for typos.

Yours sincerely,

Cristina Becchio

*** Response to Reviews**

In response to review 1:

- *Reviewer #1: This is a much improved version of the original paper. I liked it and recommend publication. I wonder, however, whether B&B could devote some further effort toward clarifying why allochiria and prior entry support their main contention, that is that neglect "...disrupts the spatio-temporal conditions of the existence of one side of space..". As of now, the link between those two syndromes and the hypothesis is extremely vague.* We revised the conclusive section.

In response to review 2:

- *The MS needs a thorough check for typos (text and references).* We checked both text and references.

Yours sincerely,

Cristina Becchio

*** Manuscript**

The ontology of neglect

Cristina Becchio (becchio@psych.unito.it)
Centre for Cognitive Science,
Department of Psychology
via Po 14 - 10123 Torino (Italy)

Cesare Bertone
CTAO, Centre for Theoretical and Applied Ontology, via S. Ottavio 20
10124 Torino (Italy)

Address for correspondence: Cristina Becchio
Centro di Scienza Cognitiva
Università di Torino
via Po 14, 10123 Torino, Italy
phone: 011-6703072
fax: 011-8159039
e-mail: becchio@psych.unito.it

Abstract. As shown by neuroscientific evidence, neglect may occur without elementary sensorimotor impairments. The deficit is to be found at a higher, more abstract level of representation, which prevents the patient not only from seeing, but from conceiving the contralesional space. By analysing a series of neuropsychological results, in this paper we suggest a crucial role of time for the construction of a world: on this basis, we try to explain how it is possible that half the ontology gets lost. The analysis of the ontological implication of neglect will allow us to shed light on manifestations of the pathology apparently disconnected.

Keywords: unilateral neglect, ontology, time, temporal features, allochiria.

> "…it might be the case that we find certain aspects of neglect puzzling, because we don't find the whole business of neglect puzzling enough." (Bisiach and Rusconi, 1990)

Unilateral spatial neglect

Unilateral neglect is a condition which has generated a great deal of interest in the past decade, as it reveals a vast amount of often bewildering behavioural manifestations. Patients suffering from unilateral spatial neglect fail to respond to stimuli, objects and even people located on their contralesional side – more frequently, the left hemispace. Depending on the severity of the pathology, neglect may be noticed merely by observing the patients' spontaneous behaviour: patients with neglect may not notice objects on the left of a scene, may not eat food on the left side of the plate, may ignore the left part of words. If the examiner approaches them from the left side, they may address their responses to the opposite side, even if nobody is there (De Renzi *et al*., 1982). They may bump into walls, doorways, and objects on the left side. Even in absence of dressing apraxia, they may forget to put on the left sleeve of their jacket or the left shoe. Other behavioural signs of left neglect include shaving or applying make-up only to the right side of the face. An endless list of examples could be given.

Some of these behaviours may seem similar to those performed by subjects affected by homonymous hemianopia, a visual field disorder frequently observed after postchiasmatic brain damage. Similarly to neglect patients, patients with left hemianopia may show difficulties in detecting stimuli and finding objects in the left visual space. They may not avoid obstacles on the left side, bumping into people approaching them from that side, and may have difficulties with reading.

Given these similarities, which may render the diagnosis of neglect problematic (Walker *et al.,* 1991), one might conceive that patients show left neglect just because, as hemianoptic patients, they *don't see* the left side of the visual world. This hypothesis is nevertheless falsified both at the anatomical level and at the functional level (see Kerkhoff, 2001). In hemianopia, no visual information can be detected in the contralateral visual field. The spatial representation of both hemispaces is nevertheless intact and hence it is sufficient that the patient turns his head to process information from the left side of space. In neglect, as we will see, the deficit is to be found at a higher, more abstract level of representation, preventing the patient not only from seeing, but from conceiving the contralesional space.

The hemiontology[1] of neglect

Unlike subjects affected by hemianopia, neglect patients not only don't see stimuli presented in the contralateral half of space, but behave as if that half of space did *not exist* and *never had existed*. Indeed, the most astonishing aspect of neglect is perhaps this: patients suffering from it, not only are unable to *perceive* the left side of space, but are not even able to *conceive* it (Bisiach, 1993).

If unlike the hemianoptic patient, the patient suffering from neglect doesn't turn his head towards the left, this is because there is no left side of the world on which to shift his gaze.

The neglect patient is unable to conceive the part of the world that the hemianoptic patient simply doesn't see. The difference is not marginal (see Table 1 for two contrasting case examples).

Insert Table 1 about here

The world that the neglect patient perceives is also the world that he conceives: he misses nothing. In this sense, the perceived world is not half the world, but the whole world, all the world that the neglect patient is able to conceive.

We don't see the world behind us but nevertheless know a world exists behind us: the world stretches beyond the boundaries of the visual field. For a subject with neglect, the world doesn't stretch beyond the boundaries of the right hemifield.

Insert Figure 1 about here

In neglect the left side of the world doesn't exist: or rather, there is no half side of the world, since there is no world stretching beyond the ipsilesional space[2].

Similar considerations can be proposed for object-centred neglect, where that being neglected is not the half side of space but the half side of each object (Driver and Halligan, 1991; Driver *et al*., 1994; Tipper and Behrmann, 1996). One might think that the left-hand side of the

[1] In philosophy the term ontology is used with different meanings. In this paper the term indicates "what there is", i.e. the real world, the whole of existing things.

[2] By positing that the neglect results in a disruption of the reality of the contralateral hemispace, we do not mean to deny that the stimuli presented in the contralateral hemispace may influence the processing of other data. Depending on the relevance of the stimuli, pre-attentive processing up to the level of meaning can take place in the neglect field without awareness (Berti and Rizzolatti, 1992). What we suggest is that those same stimuli don't gain access to existence.

object is as if occluded: the subject with neglect doesn't perceive it, but knows that it is there. This interpretation is nevertheless ruled out by empirical evidence: patients affected by neglect not only fail to respond to the left hand-side of the object, but behave as if the contralateral half of the object had never existed.

Nothing to neglect

Although not always explicitly stated, the common assumption is that this occurs because the patient with neglect is, in general, not aware of his deficit, but, as Halligan and Marshall (1998) note, this is often just not true: many patients with neglect have considerable conceptual and experiential insight into their deficit and its consequences[3]. The example reported by the authors is that of PP, a woman affected by visual neglect, showing a good insight into her neglect. In an interview recorded by the authors, PP provides a detailed account of how neglect affects the day-to-day running of her life: she reports problems with dressing and grooming, difficulties in finding things in peripersonal space ("It takes a long time to find things if they are on the left hand side…"), and in navigating in extrapersonal space ("I kept turning to the right…"). PP begins then to expound her own phenomenology of neglect:

> …I knew the word "neglect" was a sort of medical term for whatever was wrong but the word bothered me because you only neglect something that is actually there, don't you? If it is not there, how can you neglect it? It doesn't seem right to me that the word neglect should be used to describe it. I think they thought I was definitely, deliberately not looking to the left. I wasn't really. It was painful looking to the left…People think you are not looking…you are neglecting to look but it's not there. If it is not there you are not neglecting it.

As it can be seen, PP has taken issue with the term "neglect", but from her perspective, there is nothing to neglect: it is rather that the left space and the contents thereof are simply not there.

A break-down of spatial awareness

The world that the neglect patient *perceives*, we argued, is also the world that he *conceives*. Stating this we intend to mark the difference between neglect and non-cognitive disorders, like hemianopia.

The case of PP forces us however to investigate more precisely the sense of this statement. That the neglect patient doesn't conceive half the world is in fact true in a sense, but false in another. Patients like PP *know* perfectly well that people have two eyes, two arms and two legs,

[3] For more details see Marcel *et al*. (2004).

nevertheless, when asked to sketch a person, reliably they draw only one eye, one arm or one leg to the right of the frontal configuration.

A similar dissociation is evident in clock drawing tasks: patients who clearly know how many numbers there are on a standard clock will nonetheless only reproduce numbers from 12 to 6, insisting that their drawing is finished and complete.

Rode *et al.* (2004) asked a patient with unilateral neglect to evoke mentally the map of France in two different conditions. In the first condition, he was asked to imagine the map of France and to list all the towns that he could 'see'. In the second condition, he had to remember and name as many French towns as possible, without being instructed to form a mental image. Left neglect was observed in the first condition, but not in the second. When explicitly asked to imagine the map of France, the patient systematically omitted towns located on the western part of the map. However that part of geographical knowledge could be recalled from a linguistic description, clearly indicating that the representational neglect shown by the patient did not result from a memory disturbance but was rather due to a disturbance in the analogical representation[4].

The patient *knows* that in France there is town called Bordeaux, but Bordeaux disappears from his conception when the task requires him to form a *spatial* representation.

These and other observations enlighten the *spatial* character of neglect: as Berti (2000) notes, what is impaired in neglect is not the representation and the awareness of the stimuli *per se*, but the representation of the left space.

In this paper we don't intend to challenge the view that neglect is a spatial disorder. What we do want to insist upon, however, is that the unilateral loss observed in neglect cannot be attributed to a disorder of spatial representation only. It must necessarily involve another dimension. This dimension, we suggest, is time.

Beyond space

The notion that neglect patients suffer from a 'representational map reduced to one half' was explicitly and definitively presented to the scientific community by Bisiach and Luzzati (1978). The authors asked two patients with right brain lesions to imagine themselves at one end of a well-known square (Piazza del Duomo in Milan) and describe all the business places around the square.

[4] It has been proposed that representational neglect could be due to a defective spatial working memory (Beschin *et al.*, 1997). Although a role for mnemonic impairment cannot be ruled out in some cases, it is nevertheless difficult to see how it could account for Rode *et al.*'s findings, especially as the patient of Rode *et al.* tend to follow a proximity criterion in naming towns.

As one would expect in the hypothesis of a defect of space representation, both patients failed to recall shops, cafes, etc., on the left.

The next step in the experiment was for subjects to imagine themselves looking at the cathedral from the opposite end of the square. Remarkably, in this latter condition, patients named the previously neglected places but omitted those recalled just a few moments before.

Even more astonishing is the fact that subjects did not show any dismay. It should be noted that the subjects in question did not present any mnemonic impairment and that they probably would have been surprised - at least as anyone of us would have been – if they had seen an object disappearing instantaneously on their right (the countercheck had not been done). How is it possible, when they take the second perspective, for them not to be aware of the contents of their own output when they reported the view from the opposite end of the piazza?

What is striking with respect to other examples of dissociated performance is that here the dissociation originates from a mere shift in perspective. In the Rode et al. (2004) study, the dissociation could be interpreted as dissociation between propositional representation (intact) and analogical representation (impaired). In the experiment of Piazza del Duomo the dissociation affects two images of the same square.

Ontological implications

Imagining themselves standing with their back turned to the cathedral, patients recalled half the square. Imagining themselves standing at the opposite end, patients recalled the other half of the imagined scene. Even though they remembered both halves, they were nevertheless unable to recall the whole square at any one time. Why? Why didn't they stick the two halves together?

Berti and Rizzolatti (1992) propose that the encoding of space is a necessary prerequisite for conscious perception. If spatial encoding is prevented or impaired, as it is in neglect, the presence of the stimulus does not enter consciousness. With respect to Bisiach and Luzzatti's (1978) experiment, a lack of spatial awareness *per se* doesn't however seem to constitute a sufficient explanation: a spatially constrained disorder of awareness (Berti, 2000) might explain why, at any one moment, the patient is unable to represent the whole scene, not why the two halves don't form a whole.

The lack of awareness must concern not only the left side of *space*, but its *absence*. The contralesional space is not merely neglected: its absence is indeed lacking.

The mere absence implies that something is missed: something that has been, is no longer present. In neglect the left side of space is not merely not present: it is this 'not present' that is lacking. This absence of what is lacking reveals a fracture which is not only spatial, but temporal.

Whilst the mere absence simply implies that the object is not present, the absence of what is lacking requires in fact not only that the object *doesn't exist in the present,* but that *it had never existed* and *never would exist.*

Time and ontology: abnormal temporal dynamics in neglect[5]

Time is an indispensable attribute for external realities (see Becchio and Bertone, 2003): objects exist before their apparition (*permanence of anteriority*) and continue to exist even when they ceased to be visible (*permanence of posteriority*).

Despite our impression of a full and coherent world as immediate and instantaneous, 'seeing' is itself a temporal fact, requiring an integration over time (Humphreys, 1997). Since visual information is sampled at high resolution over only a few degrees of visual angle at the fovea, a complete representation of a scene requires the contents of individual eye fixations to be integrated over space and time (Resink, 2000). In the primary visual cortex, the retinal image is constructed anew at each eye fixation, overwriting all information previously encoded. Without re-mapping to maintain and re-locate neural activity corresponding to these inputs, this general overwriting phenomenon would lead to the disappearance of relevant information across ocular shifts: the world would appear as a sequence of non–integrated visual snapshots, at different spatial scale (Pisella & Mattingley, 2004).

Re-mapping deficits in neglect are suggested by studies requiring patients to make two successive saccades in order to fixate two sequentially flashed targets (double-step paradigm). If the two targets (A and B) are extinguished during the execution of the first saccade, then the generation of a spatially accurate second saccade requires re-mapping for updating the spatial representation of the extinguished target B. In a study by Duhamel *et al*. (1992), the patient, showing neglect in consequence of a frontoparietal damage, performed well with targets flashed first into the right field and then into the left field. When she was asked to do the same task with a target flashed first in the left field and then in the right field, she completed the first saccade correctly, but never acquired the second target, even though this required her to make a saccade in the ipsilesional direction.

Examining patients with unilateral lesions of various structures, Heide *et al*. (1995) found that both right and left lesions of the parietal posterior cortex (PPC) caused errors in double-step saccades. Each pair of targets was located either in the same hemifield (within–hemifield condition) or in different hemifields (between-hemifields condition). Both patients with right and left PPC lesions showed an elevated percentage of errors when in double–step saccades that involved

[5] A review of the temporal deficits in neglect is beyond the scopes of this work. Our analysis will be thus limited to those temporal aspects that – this is our suggestion – contribute to the unilateral of reality.

crossing the midline (between-hemifields condition). In addition, patients with right PCC – all of whom showed initially neglect – showed significant errors under conditions in which double-step saccades had to be performed entirely within the left visual field.

From these results, a remapping deficit would be demonstrated in neglect patients within the left visual hemifield. As a consequence, updating and maintenance of spatial representation over time (persistence) may result impaired. An additional deficit may arise in the stage of selection.

Individuals without any neurological abnormality experience a significant loss of attention after engaging a target for purpose of identification (Raymond *et al*., 1992; Shapiro *et al.*, 1994; Duncan *et al*., 1994). This loss of temporal attention, known as 'attentional blink' lasts about 400ms and is usually attributed to an inability to retain usable representation of a second target while completing attentive processing of a first target.

Using standard procedure, which consists in presenting a rapid serial visual sequence (RSVP) of letters presented successively at the same location, Husain *et al.* (1997) showed that neglect patients have an abnormally severe and protracted attentional blink, lasting nearly three times as long as for healthy observers.

Husain *et al*. (1997) examined the attentional blink at one central location. In a recent single-case study Hillstrom *et al.* (2004) varied the location of the second target: whereas the first target was always presented at fixation, the second target appeared either at fixation or peripherally to the left or the right. This variation led to an interesting finding: the patient with left-side neglect showed a prolonged attentional blink in identifying the second stimulus when the second stimulus appeared contralesionally, an attentional blink of normal duration when the stimulus appeared at fixation and no significant attentional blink when the second stimulus appeared ipsilesionally. This result suggests that the temporal dynamics of attentional processing may be enhanced compared to normal performance for ipsilesional stimuli, whereas it is significantly prolonged for stimuli appearing to the left. When two objects are simultaneously presented, this abnormal temporal dynamic may lead to neglecting contralesional objects (Humphreys, 1997): if selection of ipsilesional stimuli is speeded up and there is also a spatial bias towards ipsilesional locations, then contralesional stimuli may be missed. The temporal distortion results thus in an ontological landslide, sweeping away the left side of the world.

Two halves: not a whole

We started from the experiment by Bisiach e Luzzati (1978) to introduce the hypothesis that the disorder that underlies neglect is not confined to space but also involves time. The neglect patient remembers both halves of the square, but is still unable to remember the whole square at anyone

time. If this occurs, we reasoned, this must be because the two halves of the square don't co-exist at the same time.

Insert Figure 2 about here

Experimental evidence presented in the previous section supports this conclusion. In normal conditions, re-mapping mechanisms allow the integration of successive perception in a world of temporally enduring entities. Items successively selected co-exist within a continuous space-time.

Disrupting the temporal continuity between one side of the space and the other, neglect not only prevents the representation of half the space, but renders impossible a spatial continuity between successively represented hemi-spaces. Changing point of view, as requested in the experiment of Piazza del Duomo, has thus a twofold ontological effect: one side of the space ceases to exist, the other side explodes into existence. The result is a sequence of hemi-structures independent in both time and ontology.

Conclusive considerations

Previous research on neglect has above all been concerned with what patients with neglect can do *despite* their apparent lack of awareness. The lack of awareness per se, its nature, the paradoxes it raises, have attracted comparatively little interest (Halligan and Marshall, 1998).

The idea proposed in this paper is that neglect leads to an absence, which is not a simple absence but a lack of absence. This lack of absence originates from a disruption of the conditions of existence which involves both space and time.

One of the advantages of describing neglect both in its spatial and temporal features is that it allows one to see the relation between deficits that at different levels of analysis may appear as merely concomitant symptoms. The example that we analyse in this concluding section is that of allochiria and prior entry.

Allochiria

The term allochiria indicates the spatial transposition, usually symmetrically, of a stimulus from one side of the space to the opposite side. Neglect patients may show allochiria in several tasks, such as completion of geographical maps (Battersby *et al*., 1954; Benton *et al*., 1974), verbal description (Bisiach *et al*. 1981; Guariglia *et al*. 1993), manual pointing of visual targets (Joanette and

Brouchon, 1984), drawing from memory (Halligan *et al*., 1992a; Riddoch and Humphryes, 1983), copying drawings (Halligan *et al*. 1992b).

Halligan *et al*. (1992b) described a patient who, in copying a butterfly, omitted the left wing. However, he drew some of the left-side details on the right wing (see Figure 3).

Insert Figure 3 about here

As Berti (2002) notes, the phenomenon is obviously related to the capacity of processing left-side-neglected stimuli. What is striking is the dissociation between the "what" and the "where" in the patient's experience: the "what", which is preserved, is mislocated, being transposed in the opposed side of space.

Prior entry

A similar transposition, though in the temporal dimension, exists, we suggest, with the phenomenon of prior entry.

The phenomenon, found both in the visual modality (Rorden *et al*., 1997) and the auditory modality (Karnath *et al*., 2002), consists in the fact that an ipsilesional event is perceived as occurring earlier than physically synchronous contralesional stimulus. In Rorden *et al.* (1997) study, two patients with left-sided visual extinction after right parietal damage were each presented with two unconnected bars, one in each visual field. The patients' task was to judge which appeared sooner. Both patients reported that the right bar preceded the left unless the latter led by over 200 msec, suggesting a severe bias to the right, affecting the time-course of visual awareness.

The phenomenon, we propose, may be described as a transposition in time: separate events, physically synchronous, are relocated in time so that the left-side event appears as happening later.

As in the case of allochiria, the transposition entails a dissociation: in prior entry, this dissociation takes place between the "what" and the "when".

Insert Table 2 about here

The interpretation here proposed of neglect suggests that both in allochiria and in prior entry the mislocation of the stimuli doesn't result from a defective mapping of the spatial/temporal relations between the different elements sampled. Indeed, the stimuli are not mislocated at all, but re-located in order to avoid the ontological landslide that neglect brings about.

In allochiria the contralesional stimulus escapes from neglect by moving into another space, in the phenomenon of prior entry the transposition occurs in another time. In both cases the contralesional stimulus gains an access to existence, but this access is transposed into the hemifield in which the spatio-temporal conditions of existence are preserved.

Insert Figure 4 about here

Acknowledgements

This research was supported by the Ministero Italiano dell'Istruzione dell'Universita' e della Ricerca (Firb Project, "Assessment dei disturbi della comunicazione in un'ottica riabilitativa" research code n. RBAU01JEYW_001).

References

Battersby W.S., Bender M.B., Pollack M. & Kahn R.L. (1954). Unilateral spatial agnosia (inattention) in patients with cerebral lesion. *Brain, 79*, 68-93.

Becchio C. & Bertone C. (2003). Object temporal connotation. *Brain and Cognition, 52,* 192-196.

Benton A.L., Levin H.S. & Van Allen M.W. (1974). Geographic orientation in patients with unilateral cerebral disease. *Neuropsychologia*, *12*, 183-91.

Berti A. (2000). Neuropsychological syndromes and the structure of conscious processes. In *The Emerge of the Mind*. *Proceedings of the 9th International Symposium*. Fondazione Carlo Erba.

Berti A. (2002). Unconscious processing in neglect. In: Karnath H.O., Milner D.A. & Valla G. (EDS), *The Cognitive and Neural bases of Spatial Neglect.* New York, Oxford University Press, 313-326.

Berti A. & Rizzolatti G. (1992). Visual processing without awareness: evidence from unilateral neglect. *Journal of Cognitive Neuroscience*, *4*, 345-351.

Beschin N., Cocchini G., Della Sala S. & Logie R.H. (1997). What the eyes perceive, the brain ignores: A case of pure unilateral spatial neglect. *Cortex, 33,* 3-26.

Bisiach E. (1993). Mental representation in unilateral neglect and related disorders. *Quarterly Journal of Experimental Psychology*, *46A*, 435-461.

Bisiach E., Capitani E., Luzzati C. & Perani D. (1981). Brain and conscious representation of outside reality. *Neuropsychologia*, *19,* 543-551.

Bisiach E. & Luzzati C. (1978). Unilateral neglect of representational space. *Cortex, 14*, 129-133.

Bisiach E. & Rusconi (1990). Break-down of perceptual awareness in unilateral neglect. *Cortex, 26*, 643-649.

De Renzi E., Colombo A. Faglioni P. & Gilbertoni M. (1982). Conjugate gaze paresis in stroke patients with unilateral damage. An unexpected instance of hemispheric asymmetry. *Archives of Neurology, 39,* 482-486.

Driver J. & Halligan P.W. (1991). Can visual neglect operate in object-centered co-ordinates? An affirmative single case study. *Cognitive Neuropsychology, 8*, 475-496.

Driver J., Baylis G., Goodrich S. & Rafal R. (1994). Axis-based neglect of visual shapes. *Neuropsychologia, 32*, 1353-1365.

Duhamel J.R., Goldberg M.E., Fitzgibbon, E.J., Sirigu, A. & Grafman, J. (1992). Saccadic dysmetria in a patient with right frontoparietal lesion. *Brain, 115*, 1387-1402.

Duncan J., Ward R. & Shapiro K. (1994). Direct measurement of attentional dwell time in human vision. *Nature, 369,* 313-315.

Guariglia C., Padovani A., Pantano P. & Pizzamiglio L. (1993). Unilateral neglect restricted to visual imagery. *Nature, 364,* 235-237.

Halligan P.W. & Marshall J.C. (1998). Neglect of awareness. *Consciousness and Cognition, 7,* 356-80.

Halligan P.W., Marshall J.C. & Wade D.T. (1992a). Contrapositioning in a case of visual neglect. *Neuropsychological Rehabilitation, 2,* 125-135.

Halligan P.W., Marshall J.C. & Wade D.T. (1992b). Left on the right: Allochiria in a case of left visuo-spatial neglect. *Journal of Neurology, Neurosurgery and Psychiatry, 55,* 717-719.

Heide W., Blankenburg M., Zimmermann E. & Kömpf D. (1995). Cortical control of double-step saccades: implications for spatial orientation. *Annals of Neurology, 38,* 739-748.

Hillstrom A.P., Husain M., Shapiro K.L. & Rorden C. (2004). Spatiotemporal dynamics of attention in visual neglect: a case study. *Cortex, 40,* 433-40.

Humphreys G.W. (1997) A vision over time and space. *Nature, 385,* 120-121.

Husain M., Shapiro K., Martin J. & Kennard C. (1997). Abnormal temporal dynamics of visual attention in spatial neglect patients. *Nature, 385,* 154-156.

Joanette Y. & Brouchon M. (1984). Visual allesthesia in manual pointing: Some evidence for a sensorimotor cerebral organization. *Brain and Cognition, 3,* 152-165.

Karnath H.O., Zimmer U. & Lewald J. (2002). Impaired perception of temporal order in auditory extinction. *Neuropsychologia, 40,* 1977-1982.

Kerkhoff G. (1999). In Götze R., Höfer B. (Eds.). *Alltagsorientierte Therapie.* Thieme, Stuttgart, 102-110.

Kerkhoff G. (2001). Spatial hemineglect in humans. *Progress in Neurobiology, 63,* 1-27.

Marcel A.J., Tegnér R. & Nimmo-Smith I. (2004). Anosognosia for hemiplegia: Specificity, extension, partiality and disunity of bodily unawareness. *Cortex, 40,* 19-40.

Pisella L. & Mattingley J.B. (2004). The contribution of spatial remapping impairments to unilateral visual neglect. *Neuroscience and Biobehavioral Reviews, 28,* 181-200.

Raymond J.E., Shapiro K.L. & Arnell K.M. (1992). Temporary suppression of visual processing in an RSVP task: an attentional blink? *Journal of experimental psychology. Human perception and performance, 18,* 849-860.

Resink R.A. (2000). The dynamic representation of scenes. *Visual cognition, 7*, 17-42.

Riddoch M.J. & Humphryes G.W. (1983). The effect of cueing on unilateral neglect. *Neuropsychologia*, 21, 589-599.

Rode G., Rossetti Y., Perenin M. & Boisson D. (2004). Geographic information has to be spatialised to be neglected: a representational neglect case. *Cortex, 40*, 391-397.

Rorden C., Mattingley J.B., Karnath H.O. & Driver J. (1997). Visual extinction and prior entry: impaired perception of temporal order with intact motion perception after unilateral parietal damage. *Neuropsychologia, 35*, 421-433.

Shapiro K.L., Raymond J.E. & Arnell K.M. (1994). Attention to visual pattern information produces the attentional blink in rapid serial visual presentation. *Journal of experimental psychology. Human perception and performance, 20*, 357-371.

Tipper M. & Behrmann S.P. (1996). Object-centered not scene-based visual neglect. *Journal of experimental psychology. Human perception and performance, 22*, 1261-78.

Walker R., Findlay, J.M., Young A.W. & Welch J. (1991). Disentangling neglect and hemianopia. *Neuropsychologia, 29*, 1019-1027.

Figure captions

Figure 1. Highly schematic representation of the relationship between world (ontology) and perception in normal, hemianoptic and neglect subjects. In normal conditions the world stretches beyond the perceptive field. In hemianopia the world ontology is intact: the subject doesn't perceive the left hemifield, but he knows that there must be a left hemifield. In unilateral neglect, not only the perception but the ontology is cut in half: the contralateral hemifield doesn't exist. The (half)world perceived is all that exists.

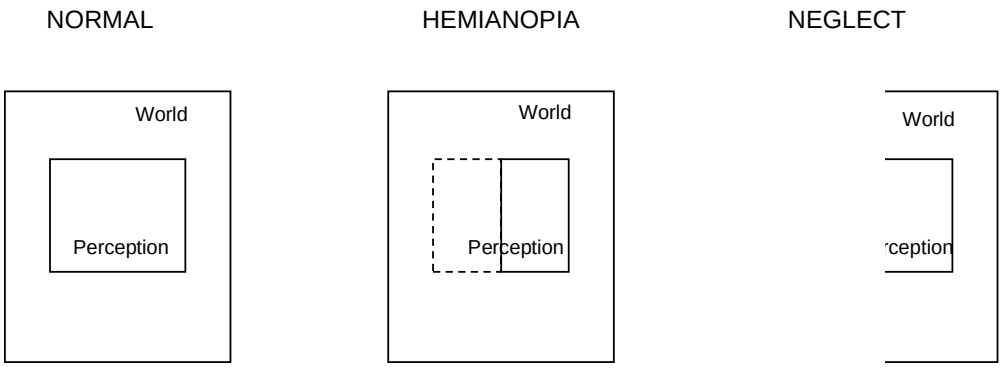
Figure 2. In normal conditions, the features of the square, independently from the order in which they have been mentioned, form a unitary spatio-temporal structure, in which they simultaneously exist. In neglect, the features that from time to time fall within the ipsilesional space are bound together in an independent structure. The relation of simultaneousness is preserved within each aggregate, but not between the features of different aggregates. (t: time).

Figure 3. Stimulus for copying (full butterfly) and patient's copy. From Halligan, Marshall and Wade (1992).

Figure 4. Schematic representation of the destiny of the contralesional stimulus in neglect, allochiria and prior entry (t. time).

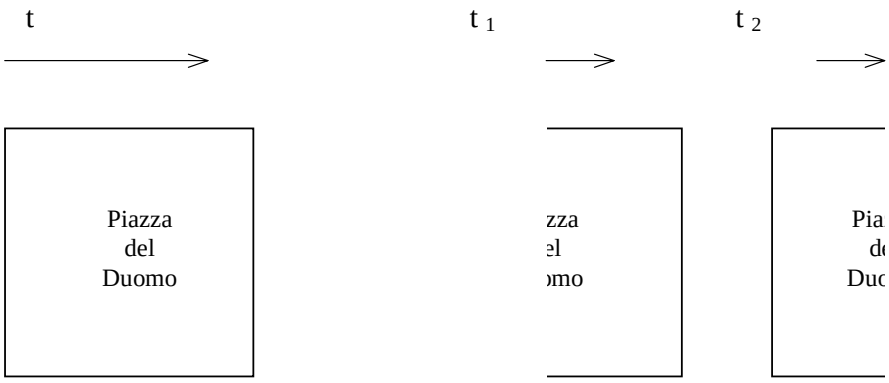
Figure

Figure 1



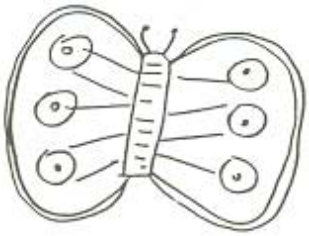
Figure

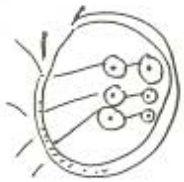
Figure 2



Figure

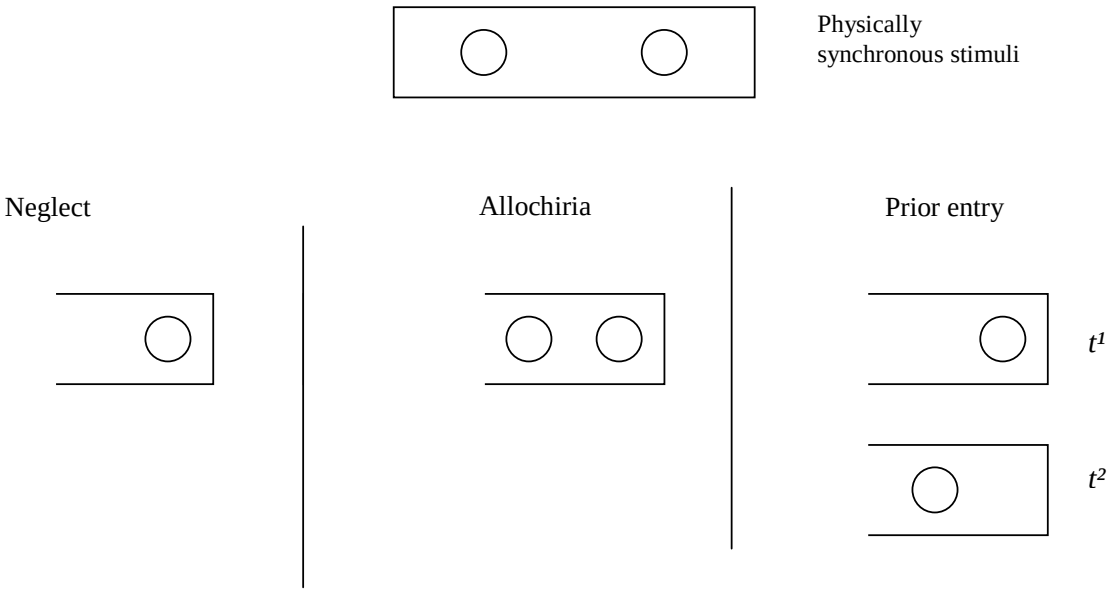
Figure 3





Figure

Figure 4



Tables

Table 1. Case examples of a patient with left-side, homonymous hemianopia (HH) and a patient with left-side neglect (N). E: examiner. Both patients had objective difficulties in reading as well as in visual exploration of the environment. From Kerkhoff (1999).

Left hemianoptic patient without neglect (HH)	Left hemineglect patient without hemianopia (N)
E: Did you experience any significant changes in vision since your illness (brain infarction)? HH: Yes, I have problems perceiving things on my left; and reading is a problem. E: Why is reading a problem? HH: It is slower than before my illness and more exhausting. Sometimes I omit words on my very left...or I omit a whole line. I only realize it at the end of a sentence when it doesn't make sense... E: Do you have any other visual impairment? HH: Yes, sometimes I bump into things or persons on my left, or detect them rather late... E: What about your orientation outside the clinic, can you find your way? HH: It's difficult, especially when many people are around, on places...or when I have to find one particular thing, i.e. in a supermarket...when it is on the left...	E: Did you experience any significant changes in vision since tour illness (brain infarction)? N: No, I haven't realized any changes. Except...the spectacles don't fit. E: Do you have problems with reading? N: No, not really. E: Do you omit words or syllables on your left side? N: no, I don't think so. E: Have you noticed that your vision is impaired on your left side? N: The left eye is fine, no problem. E: Do you sometimes bump into things or persons on your left side? N: Rarely. Well, sometimes it occurs, but that is because there are so many people in this hospital, and they don't care... E: Can you find your way inside the clinic, and outside? N: I find everything that I want to find.

Tables

Table 2. Features of allochiria and prior entry.

ALLOCHIRIA	PRIOR ENTRY
Transposition in space	Transposition in time
Dissociation between what and where	Dissociation between what and when